© March 2025 | IJIRT | Volume 11 Issue 10 | ISSN: 2349-6002

Magnitude of Arbuscular- Mycorrhizal *Gigaspora* species on famine tolerance of onion (*Allium cepa* L.)

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***Abstract*—An experiment was conducted to determine the effect of Mycorrhizal fungi inoculation on growth of onion grown under well watered and water stressed pot culture conditions. Onion (*Allium cepa* L.) seeds were planted in broadcasted. The data was collected at an interval of 15 days. Colonization of root with Arbuscular Mycorrhizal (AM) fungi occurred in under water-stressed and well-watered conditions, but the extent of AM fungi root colonization was higher under well-watered than under water stressed conditions. Regarding length of leaves, root, weight of bulb and diameter of onion after 45, 60, 75 and 90 days, data was collected. The AMF-inoculated plants had higher fresh bulb yield and mean bulb weight than uninoculated plants However, inoculation with AM fungi has improved onion bulb yield. The result indicates from AM fungi inoculation benefited more than that of especially under water-stressed conditions.**

***Index Terms*—AM fungi, inoculation, watered, water stressed, root colonization, onion.**

I. INTRODUCTION

The Onion (*Allium cepa* L.) which belongs to family Liliaceae and is one of the important horticultural crops cultivated in India.AM fungi are important in sustainable farming because they improve plant water relations and thus increase the drought resistance of host plants (Allen, E. B., and M. F. Allen. 1986). They improve disease control (Bolandnazar, S.; Aliasgharzad, N.; Neishabury, M.R.; Chaparzadeh, 2007), as well as they increase mineral uptake, which reduces the use of fertilizers. The capabilities of specific fungus-plant associations to tolerate drought are of great curiosity. Mycorrhizal inoculation with, *Gigaspora margarita* and *Gigaspora gigantea* was found to improve onion growth by enhancing the leaf area index, length of leaf, bulb yield, and water use efficiency, under both well-watered and water-deficit conditions (Bolandnazar, S. 2009). Onion as an irrigated crop, but in famine conditions limit of crop productivity, on applying different skills in cropping systems that would enable plants to better resist drought stress. It is helpful to improve crop production under arid conditions. The *Allium* species. Onion is the most widespread vegetables and show a high nutritional value on human health and beneficial to our cardiovascular system by reducing blood pressure. It is helpful to reduce the severity of cold and flu. Onion (*Allium cepa* L.) is one of the most popular ingredients in cooking. Under drought conditions AM fungi associated with plant roots enhanced growth of crop as well as productivity by improving the mineral nutritional status. By increasing the surface area of soil explored via fungal hyphae, it can be accomplished (Mushen, 2018). AM fungi also improve soil aggregation and water-holding capacity both by producing external hyphae. Mycorrhizal plants have better capacity to overcome unfavorable conditions of environment and thus produce more benefit. If tolerance of the plants to drought differs with AM fungi isolate with which plants are associated (Gupta, N. and S. Routaray 2009). The main aim of this study was to grasp effects AM fungi on bulb yield of onion. It has been observed that both sterilized and non-sterilized soil, the inoculation with AMF can cause magnificent increase in root length, leaf and diameter as well as weight of bulb onion. Nelsen and Safir (1982) testified that mycorrhizal Onion (*Allium cepa* L.) was more tolerant to water deficit stress than non mycorrhizal one.

II. MATERIAL AND METHODS

An experiment was conducted during 2015-16 to determine the effect of arbuscular mycorrhizal fungi inoculation on growth of onion grown under well watered and water stressed pot culture conditions. The data was collected at an interval of

15 days i.e. after 45, 60, 75 and 90 days. The factors were irrigation intervals (2, 4 and 8days), Arbuscular Mycorrhizal Fungi (AMF) species, (*Gigaspora margarita and Gigaspora gigantea*) and Non-mycorrhizal (NM) as control plants. Onion (*Allium cepa* L.) the cloves (seeds) were disinfected for15 min in 1% sodium hypochlorite and sown in sandy loam Fifteen grams of inoculum (spore, hyphae, AM root fragment and soil) were mixed to one kg of the medium. The control received the same amount of sterilized inoculum. After seedling emergence, their roots were washed, cut into 1cm long pieces and mixed thoroughly. The fragments then were cleared with 10% KOH and stained with 0.05% (w/v) trypan blue in lactoglycerol (Phillips and Hayman, 1970). Percentage of mycorrhizal colonization was determined by gridline intersect method (Furlan and Fortin, 1973). At transplanting (8weeks after sowing) root colonization occurs in seedlings.

III. RESULTS AND DISCUSSION

Effect of water stress on length of leaves and root of onion after 45, 60, 75and 90 days.

The effect of water stress on growth response of onion was studied with and without AM fungi after 45, 60, 75 and 90 days. The growth parameters like root length, and leaf length was recorded in control and mycorrhizal plants. The water stress was given at 2-, 4- and 8-days interval in mycorrhizal plants whereas the control plant was watered with 2 days interval. The length of leaf recorded after 45 days was 26cm in control plants whereas it was 33, 32 and 31cm in mycorrhizal plants watered with 2-, 4- and 8-days interval respectively. After 60 days the length of leaf recorded was 34, 33 and 32cm in mycorrhizal plants watered with 2-, 4- and 8-days interval respectively whereas it was28 cm in control plants. The length of leaf recorded after 75 days was 29 cm in control plants whereas it was 38, 37 and 36.50cm in mycorrhizal plants watered with2, 4 and 8 days interval respectively. The length of leaf recorded was 29cm in control plant whereas it was recorded 41, 40 and 38cm in mycorrhizal plant watered with 2, 4and 8 days interval respectively after 90 days (Table No.1). The length of root recorded after 45 days was 7 cm in control plant whereas it was 8, 9 and10cm in mycorrhizal plant watered with 2, 4and 8 days interval respectively. After 60 days the length of root recorded was 11.00, 11.50 and 12.50 cm in mycorrhizal plant watered with 2-, 4- and 8-days interval respectively whereas it was9 cm in control plant. The length of root recorded after 75 days was11.00cm in control plant whereas it was 12.60, 15.00 and16.50 in mycorrhizal plant watered with 2-, 4- and 8-days interval respectively. The length of root recorded was 13.00cm in control plant whereas it was recorded 14.55, 16.00 and15.80cm in mycorrhizal plant watered with 2-, 4- and 8-days interval respectively after 90 days (Table No.1). The mycorrhizal plant showed better growth after 45, 60, 75 and 90 days as compared to control plant. The results were significant at $P \leq 0.05$ level.

Table1: Effect of water stress on length of leaf and root of Onion after 45, 60, 75 and 90 days

No. of days	Parameter	C	E	E4	E8
45 days	Leaf length cm	26.00 ± 1.83	33.00 ± 1.83	32.00 ± 1.83	31.00 ± 1.83
	Root length cm	07.00 ± 1.83	8.00 ± 1.83	9.00 ± 1.83	10.00 ± 1.83
60 days	Leaf length cm	28.00 ± 1.83	34.00 ± 1.83	33.00 ± 1.83	32.00 ± 1.83
	Root length cm	9.00 ± 1.83	11.00 ± 1.83	11.50 ± 1.86	12.50 ± 1.77
75 days	Leaf length cm	29.00 ± 1.83	38.00 ± 1.83	37.00 ± 1.83	36.50 ± 1.75
	Root length cm	11.00 ± 1.83	12.60 ± 1.83	15.00 ± 1.83	16.50 ± 1.75
90 days	Leaf length cm	29.00 ± 1.83	41.00 ± 1.83	40.00 ± 1.83	38.00 ± 1.83
	Root length cm	13.00 ± 1.83	14.55 ± 1.83	16.00 ± 1.83	15.80 ± 1.79

C- Control, E-Experimental watered after 2 days, E4- watered after 4 days, E8- watered after 8 days ± = SE

After 45 days the diameter of onion bulb recorded was 10.10 cm in control plant whereas it was 12.20, 11.30 and 10.70 cm in mycorrhizal plant watered with 2, 4and 8 days interval respectively. The diameter of Onion bulb after 60 days recorded was 10.80 cm in control plant whereas it was 12.80, 11.90 and 11.40 cm in mycorrhizal plant watered with 2, 4 and 8 days interval respectively. The diameter of Onion bulb recorded after 75 days was 13.90, 13.20 and 12.80 cm in mycorrhizal plant watered with 2-, 4- and 8-days interval respectively whereas it was 11.20 cm in control plant. After 90 days diameter of Onion bulb recorded was 11.40 cm in control plant whereas it was recorded 15.00, 14.30 and 13.70 cm in mycorrhizal plant watered with2, 4- and 8-days interval respectively (Table No.2). The mycorrhizal plant showed better growth after 60 and 90 days as compared to control plant. The results were significant at P≤ 0.05 level. The weight of Onion bulb recorded after 45 days was 59.50 gm in control plants whereas it was 71.00, 67.00 and 62.00 gm in mycorrhizal plants watered with 2-, 4- and 8-days interval respectively. After 60 days the weight of Onion bulb recorded was 75.40, 69.30 and 63.50 gm in mycorrhizal plant watered with 2-, 4- and 8-days interval respectively whereas it was 61.50 gm in control plant. After 75 days the weight of onion bulb recorded was 65.70 gm in control plant whereas it was 77.50, 72.70 and 67.20 gm in mycorrhizal plant watered with 2, 4 and 8 days interval respectively. Weight of Onion bulb recorded was 69.40 gm in control plant whereas it was recorded 90.00, 75.80 and 71.60 gm in mycorrhizal plant watered with 2, 4 and8 days interval respectively after 90 days (Table No.2). The mycorrhizal plant showed better growth after 60 and 90 days as compared to control plant. The results were significant at P≤ 0.05 level.

Table2: Effect of water stress on diameter and weight of onion bulb after 45, 60, 75 and 90 days

No. of days	Parameter	C	E	E4	E8
45 days	Diameter of bulb(cm)	10.10 ± 1.96	12.20 ± 1.87	11.30 ± 1.87	10.70 ± 1.77
	Weight of bulb (gm).	59.50 ± 1.97	71.00 ± 1.83	67.00 ± 1.83	62.00 ± 1.83
60 days	Diameter of bulb(cm)	10.80 ± 1.90	12.80 ±1.79	11.90 ± 1.83	11.40 ± 1.94
	Weight of bulb (gm).	61.50 ± 2.01	75.40 ± 1.87	69.30 ± 1.87	63.50 ± 1.94
75 days	Diameter of bulb(cm)	11.20 ± 1.94	13.90 ± 1.83	13.20 ± 1.97	12.80 ± 1.87
	Weight of bulb (gm).	65.70 ± 2.01	77.50 ± 1.94	72.70 ± 1.87	67.20 ± 1.87
90 days	Diameter of bulb(cm)	11.40 ± 2.01	15.00 ± 1.83	14.30 ± 1.97	13.70 ± 1.87
	Weight of bulb (gm).	69.40 ± 2.01	90.00 ± 1.83	75.80 ± 1.87	71.60 ± 1.87

C- Control, E-Experimental, watered after 2 days, E4- watered after 4 days, E8- watered after 8 days ±=SE

Effect of water stress on number of propagules per 100 gm of soil and percent root colonization of onion after 45, 60,75and 90 days

The number of propagules per 100 gm of rhizosphere soil of onion plants watered with two days interval was recorded 304, 352, 391 and 502 after 45, 60, 75and 90 days respectively. The percent root colonization reported in these plants was47, 52, 61 and 69 after 45, 60, 75 and 90 days respectively. The number of propagules per 100 gm of soil of onion plants was recorded 240, 295, 347 and 479 after 45, 60, 75 and 90 days respectively in plants watered with four days interval. The percent root colonization reported in plants watered at the interval of 4days was 44, 49, 58 and 64 after 45, 60, 75 and 90 days respectively. The plants watered at the interval of eight days showed minimum number of AM propagules and lowest root colonization. It was 205, 256, 308 and 426 after 45, 60, 75 and 90 days respectively. The number of propagules decreased as the water stress was increased. The percent root colonization reported in plants watered at the interval of 8 days was40, 46, 57 and 60 after 45, 60, 75 and 90 days respectively (Table No.3). The results are significant at P≤0.05 level.

Table No.3: Effect of water stress on percentage root colonization and number of propagules per 100 gm of soil of garlic after 45, 60, 75 and 90 days

Treat ment	45 days		60 days		75 days		90 days	
	NAMP	RC	NAMP	RC	NAMP	RC	NAMP	RC
C	-	-	-	-	-	-	-	-
E	304 ± 1.83	47 ± 1.83	352 ± 1.83	52 ± 1.83	391 ± 1.71	61 ± 1.83	502 ± 1.83	69 ± 1.83
E4	240 ± 1.83	44 ± 1.83	295 ± 1.83	49 ± 1.83	347 ± 1.15	58 ± 1.83	479 ± 1.83	64 ± 1.15
E8	205 ± 1.83	40 ± 1.83	256 ± 1.83	46 ± 1.83	308 ± 1.83	57 ± 2.94	426 ± 1.83	60 ± 1.83

Values are significant at P≤0.05level.

NAMP = Number of AM propagules RC = % root colonization C- Control E -Experimental, Watering after 2 days, E4- Watering after every 4 days, E8- Watering after 8 days. ± = SE AMF colonization (Table 3) improved the leaf length, root length, (Table 1) as well as diameter and weight of bulb ratio significantly (Subramanian, K.S., P. Santhanakrishnan and P. Balasubramanian, (2006.). Water stress had significantly reduced bulb yields in un-inoculated plants (Mushen,T.A. and Ali B.Z. 2015). However, inoculation with AM fungi has upgraded garlic bulb yield. The length of leaf recorded after 75 days was 29 cm in control plants whereas it was 38, 37 and 36.50 cm in mycorrhizal plants watered with2, 4 and 8 days interval respectively. The length of leaf recorded was 29cm in control plant whereas it was recorded 41, 40 and 38 cm in mycorrhizal plant watered with 2, 4and 8 days interval respectively after 90 days The length of root recorded was 13.00 cm in control plant whereas it was recorded 14.55, 16.00 and 15.80 cm in mycorrhizal plant watered with 2, 4 and 8 days interval respectively after 90 days (Table No.1).The mycorrhizal plant showed better growth after 45, 60, 75 and 90 days as compared to control plant. After 90 days diameter of onion bulb recorded was11.40cm in control plant whereas it was recorded15.00, 14.30 and 13.70cm in mycorrhizal plant watered with2, 4 and 8 days interval respectively (Table No.2). The mycorrhizal plant showed better growth after 60 and 90 days as compared to control plant. Weight of onion bulb recorded was 69.40gm in control plant whereas it was recorded 90.00, 75.80 and 71.60gm in mycorrhizal plant watered with 2, 4 and8 days interval respectively after 90 days. The plants watered at the interval of eight days showed minimum number of AM propagules and lowest root colonization. It was 205, 256, 308 and 426 after 45, 60, 75 and 90 days respectively. The number of propagules and root colonization arise with decreased as the water stress was increased (Ruiz-Lozano, J. M. and R. Azcon 1996). The symbiotic association between plant-mycorrhiza has seen increased interest and evidenced for direct recycling of nutrients from organic matter to plants by mycorrhizal fungi. The plant mycorrhiza association is mostly studied for many crop plants for enhancement in plant growth and yield due to increased supply of phosphorous to the host plants. Therefore present investigation was undertaken to find out the exact interrelationship between AM fungi and yield of Onion (*Allium cepa* L.). Arbuscular mycorrhizal fungi improved Onion growth and development in comparison with non-mycorrhizal ones. This improvement resulted from increasing plant height which led to greater leaf area and probably photosynthesis capacity both leading to greater larger bulb. Increasing plant size and yield (Charron et al., 2001a); and enhancing chlorophyll content by AMF colonization. Mycorrhizal onion had greater size of bulb than control plants at first harvest, implying that bulb initiation and bulbing process occurred earlier and produced faster in mycorrhizal plants than non-mycorrhizal ones (Table 1). In control plants, bulbing occurred 10-15 days late. Our results agree with findings of Charron et al.(2001b), who reported that mycorrhizal onion reached to marketable size 2-3 weeks earlier than non-mycorrhizal Onion.

IV. CONCLUSION

The mycorrhizal colonization improves onion seedling endurance and establishment that increased its growth and development which led to producing bigger bulb and greater yield. Hence, it indicates that the presence of arbuscular mycorrhizal association affects the growth and development of onion plant.

V. ACKNOWLEDGEMENT

The author is thankful to the management of N.V.P. Mandal and the Principal of Arts, Science and Commerce College, Lasalgaon Dist. Nasik for permitting to complete the undertaken research work in the authorized research laboratory and providing the facilities during conducting research work.

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